Evaluation of noise environments during daily activities of university students

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ABSTRACT

Noise conditions specifically in areas inside university facilities and its impact on the quality of life of university students aretopics that have received little attention. In this paper, a study of the noise conditions in which university students of various institutions in Madrid carry out their daily studies. A representative number of measurements were carried out using noise dosemeters and dataloggers in order to evaluate the levels of noise, noise dose and exposure to noise during study period and extracurricular activities. The results obtained in these measurements were compared with the recommendations given by current environmental noise regulations.This paper was complemented with a survey to get to know how students perceive the exposure to noise inuniversity environments.

Keywords: university environments, noise at universities, noise dose.

1. Introduction

Throughout the day, students carry out various activitieson and off campus. Atthe university facilities, the main source of noise is the students themselves since universities are used for studying as well as socializing [1]. Traffic noise in surrounding areas [2], public works, etc., are external sources of noise that directly affect the acoustic quality in study facilities. Outside the university facilities, students mainly spend their time participating in sports, working, leisure activities, etc. During this time, they are exposed to different types of urban noise caused by different sources ranging from traffic noise to very high levels of music at discotheques [3, 4]. Normally in these places, the allowed level of noise is exceeded. Unfortunately, there are no specific regulations about noise in the student sector. Likewise, noise dose and noise exposure at educational facilities in the university sector is a topic that needs to been deeply studied. Most of the studies are focused on noise levels and acoustic conditioning in classrooms specifically [5-9]. Recent researches studied the effects of noise also inside of other educational facilities. Exposure to excessive noise is one major cause of hearing disorders and is associated with the sensory cells damaged in the inner ear [10, 11]. Quality of life and academic performance also are affected because noise effects. Due to these reasons is very important to deeply study the noise conditions to which university students are exposed.

Knowledge about the noise conditions in university facilities through objective measurements is very necessary to design mechanisms and strategies in order to improve the acoustics conditions inuniversity facilities and also to define parameters to develop regulations applicable to any educational sector. In this paper, a study of the different acoustical environments to which university students are exposed in their daily activities has been conducted in order to determine the most aggressive factors

and environments. The results of this study can help to future works in order to develop strategies and the necessary measures to improve the acousticconditions of university.

2. Method

Measurements were taken using dosemeters and dataloggers during study and extracurricular time. The measurementswere carried out ineducational facilities. $L_{Aeq,T}$ and $L_{C,peak}$ parameters were obtained and compared with some recommendations. Moreover,eight hours exposure to noise (E_{8h}), eight hoursnoise dose (D_{8h})andeight hours exposure level ($L_{EX,8h}$) were evaluated. Furthermore, a subjective study was conducted through a survey. This survey shows the perspective of students regarding noise in variousuniversity facilities of Madrid, Spain.

2.1. Survey

A survey was designed in order to complement this stage. The total number of respondents was 454 students of which 351 were males and 103 females. The age of the respondents was between 19 and 33, of which 385 were bachelor students, 23 master students and 46 doctorate students.The survey consisted of 13 questions of which 6 were related particularly to this study. The students were asked about the noise conditions inside the facilities as well as outside the campus and at the places where they participate in extracurricular activities. They were also asked about the use of hearing protection on and off the campus. The survey was conducted online as well as face-to-face.

2.2. Participants on measurements

63 degree, master and doctorate students (44 men, 19 women) between the ages of 19 and 32 were selected to participate in the study. For the second stage, atotal

of 33 students (17 male, 16 female) between 19 and 34 years, participated in the experiment. 12 of the participants were degree students, 9 were master students and 12 were doctorate students.

2.3. Measurement strategy and measurement equipment

In order to obtain relevant data, a measurement strategy was necessary. Factors such as theactivities of the students, the differentplacesthatthey usually frequent, as well as the difficultyof observingthe participants, were the most important factors taken into account to decide on the most appropriate measurement strategy.

The standard ISO/FDIS 9612:2009(en) *Acoustic - Determination of occupational noise exposure - Engineering method"* [12], describes three different strategies of measurement: full day measurements, based onspecific tasks and based in type of work. Taking into accountthe factors previously cited, we considered the *type of work strategy* as the most optimal method to register our measurements. In order to find out more details about the noise conditions during the daily activities of students, these measurements were conducted during ordinary study days, inside and outside of educational facilities.

According to the characteristics of our study, the most practical equipment to carry out the measurements during such a long period appeared to be a noise dose meter. We used the two-channel dosimeter UDABI-223 developed by UROS.

The use of this kind of equipment generally requires the observation of the person carrying it. Given this difficulty, and because of the different school and extracurricular activities, and the desired number of samples, a close observation was very difficultto carry out. Some alternative actions were therefore considered to verify the validity of the measures. On the one hand, training on how to use and place the measurement equipment was given to the persons being studied. Furthermore,

adocument for the registration of all daily activities was created to be able to obtain more information about the participants. The persons carrying the dosimeter were instructed on how to fill out this document, which enabled the tracking of all activities they participated in.

After the short training, the dosemeter was placed and the measurements were started. The measurement period took place during normal study days (from Monday to Friday), when the participants were available to use the equipment and when the places where they were carrying out their activities allowed the use of the dosemeter.

Finally, the measurements conducted forthis research were equivalent continuous A-weighted sound pressure level, registered along the whole measurement ($L_{Aeq,T}$), peak level registered along the whole measurement ($L_{C,peak}$), duration of the measurement (T), noise exposure registered along the measurement (E_{8h}), noise dose ($\%D_{8h}$) and noise exposure level ($L_{EX,8h}$). In order to have a better reference of the noise levels recommended for this kind of environments, we use the recommendations given by the Spanish Royal Decree R.D. 286/2006[13], R.D. 1371/2007 [14] and ISO 9612:2009 (en) [12].

3. Results

3.1. Survey results

Table 1 summarize the results of the survey. According to the results of the survey, 75% of the students perceive that in general the facilities are noisy. Likewise, 61% considers that the classrooms are noisy. 6% of responders express that at some time they have used hearing protection. 84% of the students considered the area surrounding the school facilities to be noisy. Also, they were asked about the sound conditions at the places where they carry out their extracurricular activities and 96%

believe that these environments are noisy while 19% has used hearing protection during these activities.

Insert Table 1 about here

We have analysed the results of the survey focussing on gender. The results show that 80% of the female respondents and 70% of the male respondents consider the university facilities as noisy. In addition, 76% of the female respondents and 54% of the male respondents considered the classrooms as noisy, and 6% of both female and male respondents stated that they use hearing protection during their activities in university facilities. Also, 81% of the female respondents and 87% of the male respondents find the university surrounding areas noisy. On the other hand, 97% of the female respondents and 95% of the male respondents think that the places where they develop their extra-curricular activities are noisy. A small percentage of the respondents (18% = female, 20% = male) stated that they use hearing protection during extra-curricular activities (Figure 1).

Insert Figure 1 about here

3.2. Overall results

Table 2 shows the total time of measurements. The total time of all measurements was 914.14 hours and the time average of measurement for each participant is 14.51 hours. In the case of the *school period* the total time of measurement was 382.1 hours. The minimum and maximum time was 0.90 and 13.02 hours respectively and the average was 6.07 hours. Furthermore, for extracurricular period the total time of measurement was 532.02 hours and an average of 8.51 hours where noise level measurements were carried out. The minimum time was 1.06 and the maximum time was 18 hours. This time was variable depending on the availability

of the people to use the equipment due to the different activities and the opportunity to use the device in different scenarios.

Insert Table 2 about here

Table 3 summarizes an average of the results of all measurements registered. Daily equivalent A-weighted level, $L_{Aeq,T}$; peak C-weighted level, $L_{C,peak}$;8 hours exposition level, $L_{EX,8h}$;8 hours noise dose, D_{8h};8 hours exposition to noise, E_{8h}; are included.

Insert Table 3 about here

According to the recommendations given by the R.D. 1371/2007 [14], the maximum level recommended is 60 dBA in areas around university facilities. However, 81% of participants used to spend time in areas where this level is exceeded. Furthermore the total of participants uses to spend time in areas where the maximum level (40 dBA) recommended by R.D. 1371/2007 [14] for lecture halls and classrooms (Figure 2).

Insert Figure 2 about here

Table 4 shows a review of the results for three different groups: degree, master and Ph.D during both school and extracurricular time. The $L_{Aeq,T}$ average levels during the school time period are in the range 84.2-85.6 dBA,D_{8h} between 45% and 71% andE_{8h} in the range 0.84 y 1.17 Pa^2/h. The highest average levels can be observed in the degree group.

Insert Table 4 about here

3.3. Noise dose and sound exposure.

In the case of school-time and taking the 85-percentile parameter we calculate the noise dose in a period of 8 hours. We observed that the 21% of the participants exceed the maximum noise dose of 100%. The maximum dose received during this period was 565%, and the average 63% (below the maximum dose). On the other hand, because the average school time measured was 6 hours, we considered calculating the dose again during this period. Performing these calculations, 75% of the students receive a dose above the 100% recommended. A comparison between D_{8h} and D_{6h} is showed in Figure 3(a).

For extracurricular period, 33% of the students exceed the maximum dose of 100% taking a period of 8 hours and 85-percentile. The maximum noise dose received during extracurricular period is extremely high, 1981%. The average of dose was 215%, a little more than the double of the recommended amount.

For D_{8h} and E_{8h}, highest averages of the registers are observed in extracurricular period. The highest averages values were registered in degree group. For degree group, the difference observed in D_{8h} between scholar time (71%) and extracurricular (288%) periods is around four times the average registered. This value is almost three times the maximum level of dose 100%. In the case of E_{8h}, for degree group, a difference of 2.12 Pa^2/h between both periods was observed. Furthermore, the average difference between both periods for master group is 0.33 Pa^2/h and 0.06 Pa^2/h. for Ph.D. group. A general representation of E_{8h} and E_{6h} are showed in Figure 3 (b).

Insert Figure 3 about here

4. Conclusions

A study of noise levels, noise dose and exposure to noise during study time and extracurricular time was performed.

In general, students spend more time doing extracurricular activities outside of university facilities than doing scholar activities inside university facilities. We could observe that during school time the maximum $L_{Aeq,T}$ (60 dBA) recommended is exceeded by 81% of the participants and 21% of the participants use to spend time in areas where maximum dose of 100% is exceeded. We noticed very high noise levels in the sound environments in which students develop their daily activities, especially during extracurricular activities. During these activities, collegestudents are the group that is most exposed to noise: they usually spend a lot of time in extremely noisy places like discotheques and bars. 54% of the participants were exposed to noise levels that exceeded 70 dBA and 33% received a noise dose higher than 100% during this type of activities. On the other hand, during school time the maximum $L_{Aeq,T}$ (60 dBA) recommended is exceeded by 81% as indicated by the participants. 21% of the participants were in environments that exceeded the maximum dose of 100%. All these results show that the levels of noise in areas inside university destined for study facilities are highest than recommended by recommendations.

We are convincedthat high levels of noise have direct consequences on the academic performance as well as on the physical and psychological health of students. Poor acoustic conditions maximise the noise problems and it worsens the study conditions of students. Definitely it is very important to have adequate acoustic conditions in areas designated for studying, but we also want to stress the importance of developing strategies that aim to increase awareness of noise amongst students. Combining these two variables, it would be possible to achieve good acoustic conditions which stimulate academic performance.

The results obtained in this work help us to understand in a better way the noise problem on university scene in order to carry out future works where improve of the acoustics condition is implied.

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FIGURE CAPTIONS

Figure 1. Results of the survey in function of gender. Figure 1(a) shows the results of the surveys of female responders. Figure 1(b) shows the results of the surveys of male responders. *Notes*. Numbers 1, 2, 3, 4, 5, 6, under the figures a) and b) show the number of questions of the survey, % - percentage of responders.

Figure 2. $L_{Aeq,T}$ and $L_{EX,8h}$ for each participant during school period. *Notes*. Dotted line indicates the maximum level recommended by R.D. 1367/2007 in areas around schools (60 dBA). The whiskers indicate the standard deviation. Solid line indicates the maximum level recommended by R.D. 1367/2007in lecture rooms and classrooms (40 dBA).

Figure 3. D_{8h} and D_{6hr} of each participant only during school period. *Notes*. Figure 3(a). Dotted line indicates the maximum noise dose recommended (100%). In figure 3(b) is showed a general representation of the sound exposure (E_{8h} and E_{6h}) measured for each participant.

TABLE CAPTIONS

TABLE 1. Results of the survey.

TABLE 2. Total time of measurements.

TABLE 3. Averages of the results of the measurements.

TABLE 4. Mean of results of the different groups analysed.

340 **TABLE 1. Results of the survey**

		Answers	
Studied area	**Question**	**No**	**Yes**
Inside campus	Do you consider university facilities as noisy?	25%	75%
	Do you consider classrooms as noisy?	39%	61%
	Do you use hearing protection at facilities?	94%	6%
	Do you think that University Surrounding areas are noisy?	16%	84%
Outside campus	Do you think that the places where you develop your extracurricular activities are noisy?	4%	96%
	Do you use hearing protection during extracurricular?	81%	19%

Notes. 100%=454 responders.

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342 **TABLE 2. Total time of measurements.**

Period	T_{max} **(hrs.)**	T_{min} **(hrs.)**	T_{tot} **(sec.)**	T_{tot} **(hrs.)**	T**(%)**	**Mean**
School time	13.02	0.90	1375622	382.1	42%	6.07
Extracurricular	18.00	1.06	1915288	532.0	58%	8.51
Total	22.01	6.20	3290910	914.1	100%	14.51

Notes. T_{max} - maximum time of measurement, T_{min} - minimum time of measurement; T_{tot} (hrs) – total time expressed in hours; T_{tot} (sec) – total time expressed in seconds; T(%) – total time expressed in percentage.

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344 **TABLE 3. Averages of the results of the measurements.**

Period		$L_{Aeq,T}$ (dB)	$L_{C,peak}$ (dB)	$L_{EX,8h}$ (dBA)	E_{8h} (Pa^2/h)	D_{8h} (%)	D_{6h} (%)
School time	Mean	85.5	120.4	83.0	1.14	63%	85%
	Max.	95.0	135.3	92.5	10.20	565%	753%
	Min.	45.4	67.9	42.8	0.00	0%	0%
	S.D.	13.8	15.3	13.6	2.33	120%	159%
Extracurricular	Mean	88.8	134.5	88.4	2.44	215%	-
	Max.	98.6	152.1	98.0	23.27	1981%	-
	Min.	47.0	73.3	44.4	0.00	0%	-
	S.D.	14.5	15.6	14.3	4.96	417%	-

Notes. $L_{Aeq,T}$ - equivalent continuous A-weighted sound pressure level over duration, $L_{C,peak}$ - C-weighted peak sound pressure level, $L_{EX,8h}$ - noise exposure level over 8 hours in A-weighted decibels, E_{8h} - exposure to noise in pascal-squared-hours $\%D_{8h}$ – noise dose in percentage over a period of 8 hours, $\%D_{6h}$ – noise dose in percentage over a period of 8 hours.

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346 **TABLE 4. Mean of results of the different groups analysed.**

Period	Studylevel	$L_{Aeq.T}$ (dB)	$L_{C,peak}$ (dB)	$L_{EX,8h}$ (dBA)	E_{8h} (Pa^2/h)	D_{8h} (%)	T_{tot} (hrs.)
School time	Degree	85.6	121.9	83.5	1.17	71%	213.16
	Master	86.9	118.7	83.0	1.55	64%	51.7
	Ph.D.	84.2	115.2	81.5	0.84	45%	113.9
Extracurricular	Degree	90.1	126.7	89.7	3.3	288%	311.83
	Master	87.7	142.5	87.2	1.89	165%	82.16
	Ph.D.	84.5	109.6	84.2	0.90	83%	138.0

Notes. $L_{Aeq,T}$ (dB) - equivalent continuous A-weighted sound pressure level over duration in decibels, $L_{C,peak}$ (dB) - C-weighted peak sound pressure level in decibels, $L_{EX,8h}$ - noise exposure level over 8 hours in A-weighted decibels, $\%D_{8h}$ – noise dose in percentage over a period of 8 hours, T_{tot} – total time of measurements.

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